MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2019/2020

EMG4066 – ANTENNA AND PROPAGATION

(TE)

13 MARCH 2020
9.00 a.m. – 11.00 a.m.
(2 Hours)

INSTRUCTION TO STUDENT

1.This question paper consists of 6 pages including cover page and appendices with 4 questions only.

2. Attempt **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the provided answer booklet.

Question 1

(a) Evaluate the directivity of an antenna with normalized radiation intensity given by

$$U(\theta,\phi)=\begin{cases}\sin^2\theta & , \quad 0\le\theta\le\pi,\ 0\le\phi\le 2\pi \\ 0 & , \quad \textit{elsewhere}\end{cases}$$

[10 marks]

(b) The concept of effective area (or effective aperture) is usually employed in the analysis of receiving antennas. Derive the effective area of a short dipole in terms of wave length.

[15 marks]

Question 2

A two half wave dipole array is shown in **Figure Q2**. The power of both elements is the same but there is phase shift of α between elements.

(a) Derive the equation of electric field strength for both elements (i.e. E_0, E_1) at point P, as indicated in **Figure Q2**.

[8 marks]

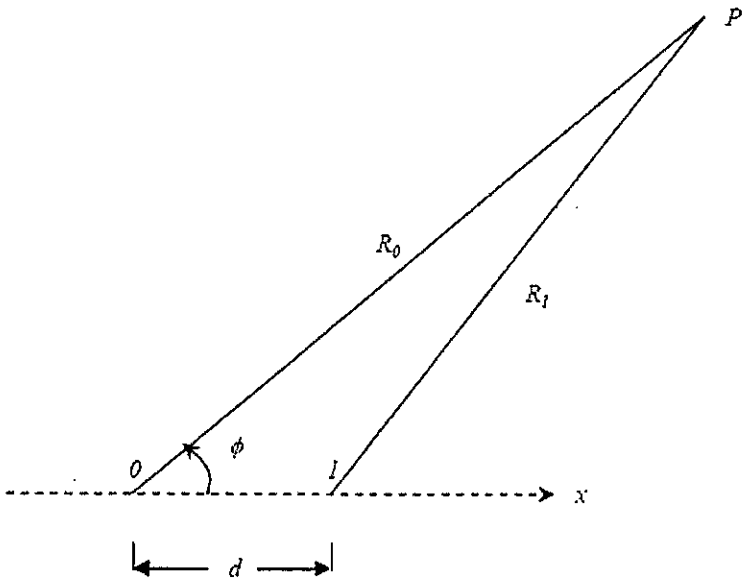
(b) Determine the equation of the sum of E_0 and E_1. State the assumption made with regards to distance and phase.

[12 marks]

(c) From part (b), determine the element factor and array factor.

[5 marks]

Continued...



A two-element array

Figure Q2

Question 3

(a) Consider a helical antenna operating on the normal mode.

(i) Write the equations for the eletrical field.

[5 marks]

(ii) Based on (i), determine the axial ratio (AR).

[5 marks]

(iii) Based on (ii), explain the effect of AR on the antenna polarization.

[5 marks]

(b) Draw the structure of typical Yagi antenna. Explain the function of each element of the Yagi antenna.

[10 marks]

Continued...

Question 4

(a) Consider a wireless communication link between transmitter and receiver with transmitting antenna gain, G_t and receiving antenna gain, G_r respectively. Prove that the receiving power P_r, as given below is valid. Where d is distance, P_t is transmitting power, λ is wavelength.

$$P_r = P_t \bullet G_t \bullet G_r \left(\frac{\lambda}{4\pi d}\right)^2$$

[15 marks]

(b) Most terrestrial communications in the VHF and UHF frequency bands propagate via direct, line-of-sight, or space waves propagation. The space wave propagation can be modeled by using direct and reflected propagation ray paths. Establish the model and derive an equation for the resultant electric field strength.

[10 marks]

Continued...

APPENDIX

Constants and Formulae (All symbols have their usual meanings)

Constants and Formulae:

Boltzmann's constant	$k = 1.38 \times 10^{-23} J/k$
Plank's constant	$h = 6.6266 \times 10^{-34} J.s$
Light velocity in free space	$c = 3 \times 10^{8} m/s$
Electron Charge	$e = 1.6 \times 10^{-19} C$
Permeability of free space	$\mu_o = 4\pi \times 10^{-7} H/m$
Permittivity of free space	$\varepsilon_o = \frac{10^{-9}}{36\pi} F/m$

$$P_{rad} = 40\pi^2 \left[\frac{L}{\lambda}\right]^2 I_m^2$$

$$AF = a_1 e^{j\alpha_1} + a_2 e^{j(\beta d\cos\theta+\alpha_2)} + a_3 e^{j(2\beta d\cos\theta+\alpha_3)} + \ldots + a_N e^{j((N-1)\beta d\cos\theta+\alpha_N)}$$

$$|AF| = \frac{\sin(N\psi/2)}{\sin(\psi/2)}, \quad \psi = \beta d\cos\theta + \alpha$$

If n is fractional or negative and $|x| \prec 1$

$$(1 \pm x)^n = 1 \pm nx + \frac{n(n-1)}{2!}x^2 \pm \frac{n(n-1)(n-2)}{3!}x^3$$

$$P_D = \frac{P_{tx}G_{tx}}{4\pi R_{tx}^2} \qquad h_{inc} = \frac{D_1 D_2}{2KR} \qquad r = \sqrt{\frac{D_1 D_2 \lambda}{D_1 + D_2}}$$

$$E = \frac{\sqrt{30P_t \bullet G_t}}{d} \qquad E_R = 2\frac{E_0}{d}\sin\left(\frac{2\pi}{\lambda} \bullet \frac{h_t h_r}{d}\right)$$

$$n = \sqrt{\varepsilon_r} = \frac{\sin\theta_i}{\sin\theta_r} = \sqrt{1 - \frac{81N}{f^2}} \qquad MUF = f_{cr} Sec\theta_i$$

Continued...

SPHERICAL COORDINATES (R, θ, ϕ)

$$\nabla V = \hat{\mathbf{R}}\frac{\partial V}{\partial R} + \hat{\boldsymbol{\theta}}\frac{1}{R}\frac{\partial V}{\partial \theta} + \hat{\boldsymbol{\phi}}\frac{1}{R\sin\theta}\frac{\partial V}{\partial \phi}$$

$$\nabla \cdot \mathbf{A} = \frac{1}{R^2}\frac{\partial}{\partial R}(R^2 A_R) + \frac{1}{R\sin\theta}\frac{\partial}{\partial \theta}(A_\theta \sin\theta) + \frac{1}{R\sin\theta}\frac{\partial A_\phi}{\partial \phi}$$

$$\nabla \times \mathbf{A} = \frac{1}{R^2\sin\theta}\begin{vmatrix} \hat{\mathbf{R}} & \hat{\boldsymbol{\theta}}R & \hat{\boldsymbol{\phi}}R\sin\theta \\ \dfrac{\partial}{\partial R} & \dfrac{\partial}{\partial \theta} & \dfrac{\partial}{\partial \phi} \\ A_R & RA_\theta & (R\sin\theta)A_\phi \end{vmatrix}$$

$$= \hat{\mathbf{R}}\frac{1}{R\sin\theta}\left[\frac{\partial}{\partial \theta}(A_\phi \sin\theta) - \frac{\partial A_\theta}{\partial \phi}\right] + \hat{\boldsymbol{\theta}}\frac{1}{R}\left[\frac{1}{\sin\theta}\frac{\partial A_R}{\partial \phi} - \frac{\partial}{\partial R}(RA_\phi)\right] + \hat{\boldsymbol{\phi}}\frac{1}{R}\left[\frac{\partial}{\partial R}(RA_\theta) - \frac{\partial A_R}{\partial \theta}\right]$$

$$\nabla^2 V = \frac{1}{R^2}\frac{\partial}{\partial R}\left(R^2\frac{\partial V}{\partial R}\right) + \frac{1}{R^2\sin\theta}\frac{\partial}{\partial \theta}\left(\sin\theta\frac{\partial V}{\partial \theta}\right) + \frac{1}{R^2\sin^2\theta}\frac{\partial^2 V}{\partial \phi^2}$$

End of paper.